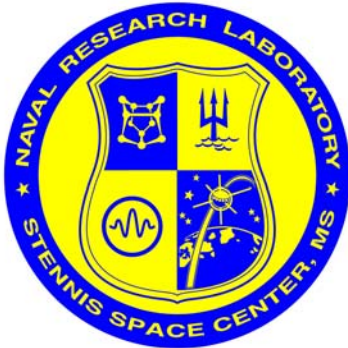


Nested Gulf of Mexico Modeling with HYCOM



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Naval Research Laboratory
Stennis Space Center, MS

HYCOM Meeting
December 6-8, 2005
University of Miami, Miami, FL

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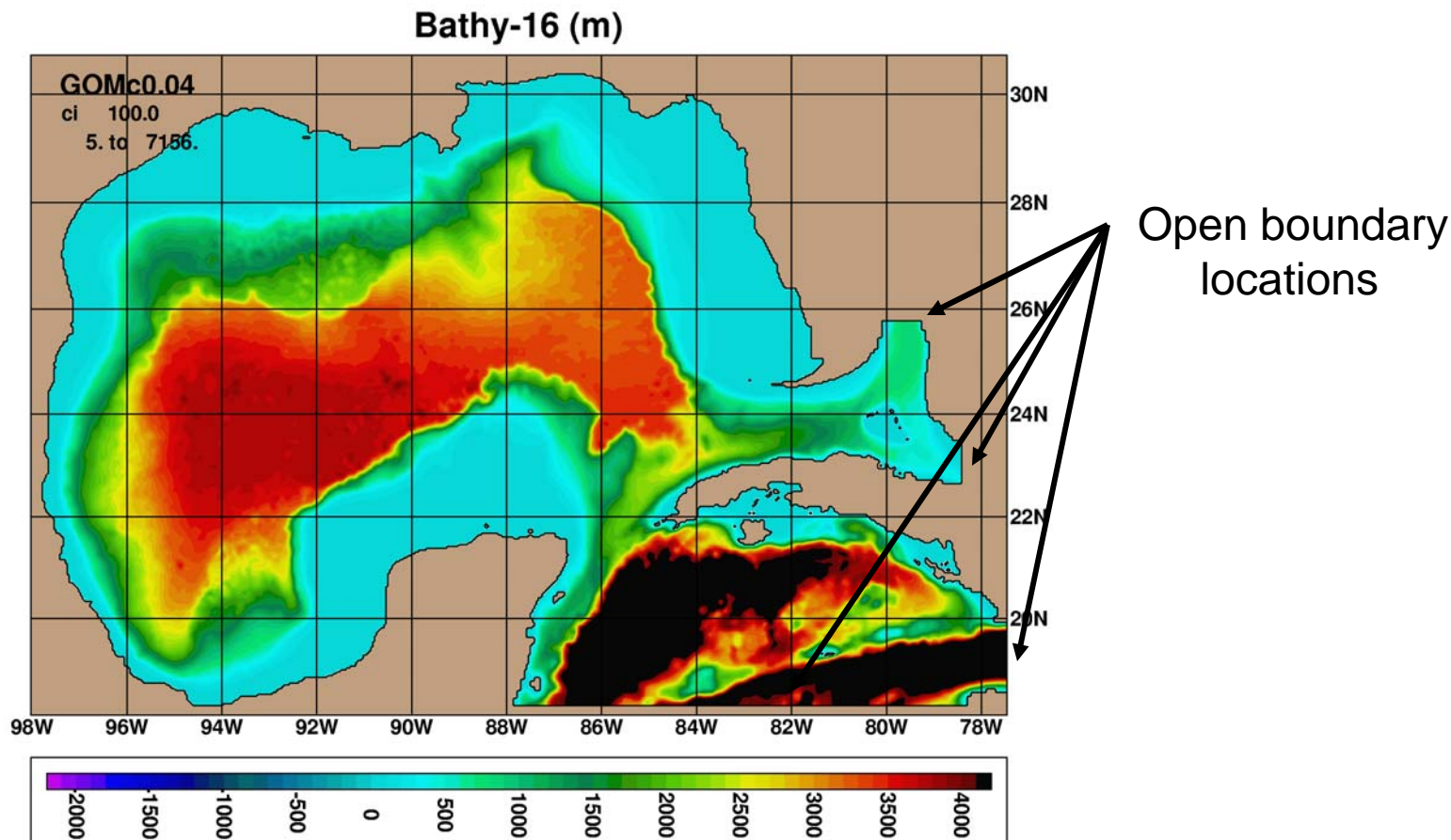
1/25° (~4 km) non-assimilative Nested Gulf of Mexico

- Initialized from January 1, 2000 1/12° Atlantic HYCOM
- Lateral boundary conditions from 1/12° Atlantic HYCOM
- Surface forcing is from 6-hourly/3-hourly NOGAPS (2000/2001)
- 20 layers in the vertical (bottom 5 from Atlantic discarded)
- 16 Rivers included as salinity flux
- GISS Mixed Layer submodel
- Bottom topography is from NRL-DBDB2
- Integrated over 2000-2001

Possible cross-shelf transport mechanisms

- Shelf break instabilities
- Shelf break flow reversals
- Eddy-eddy interactions
- Eddy-topography influence

1/25° Gulf of Mexico Model (~4 km)

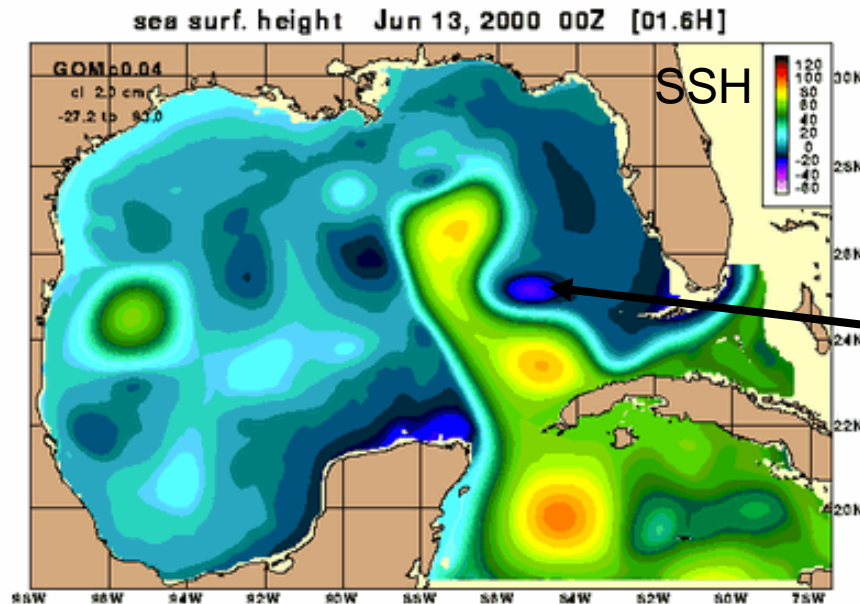


Method of Characteristics used
To update the barotropic mode

20 gridpoint buffer zone for baroclinic
mode with e-folding time 1 to 10 days

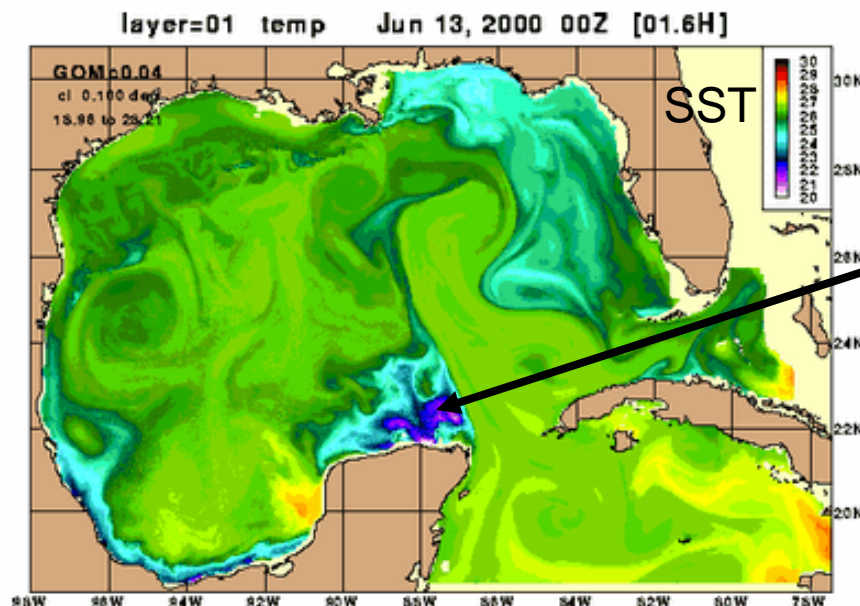
Atlantic boundary data provided daily

1/25° (~4 km) Nested Gulf of Mexico



Snapshot of SSH
and SST on June, 13
2000

Lots of cyclonic
cold core eddies
(impact of 2x res.)

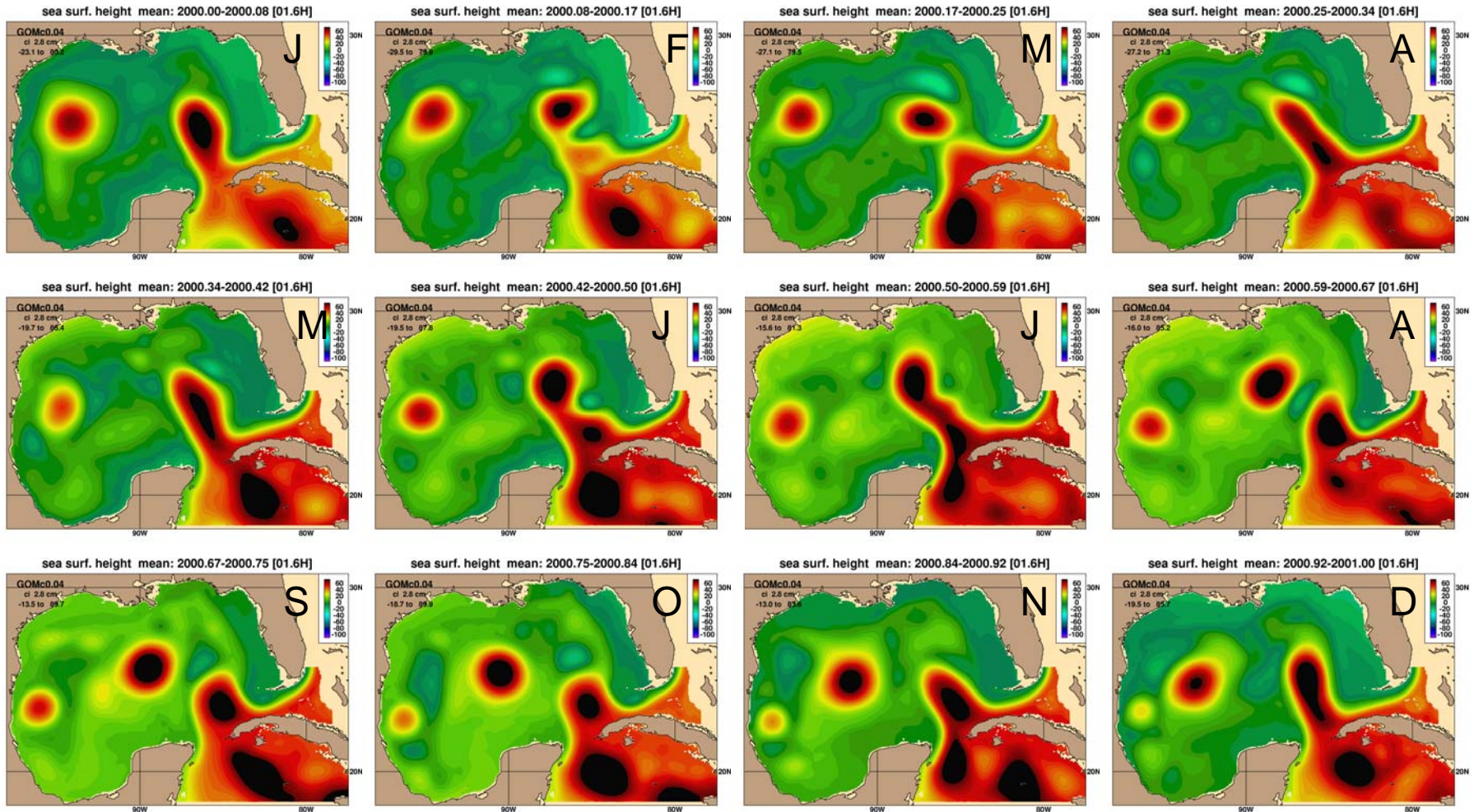


Local upwelling

1/25° Nested Gulf of Mexico HYCOM

Monthly Mean Sea Surface Height Year 2000

Evolution of Loop Current Eddy Shedding

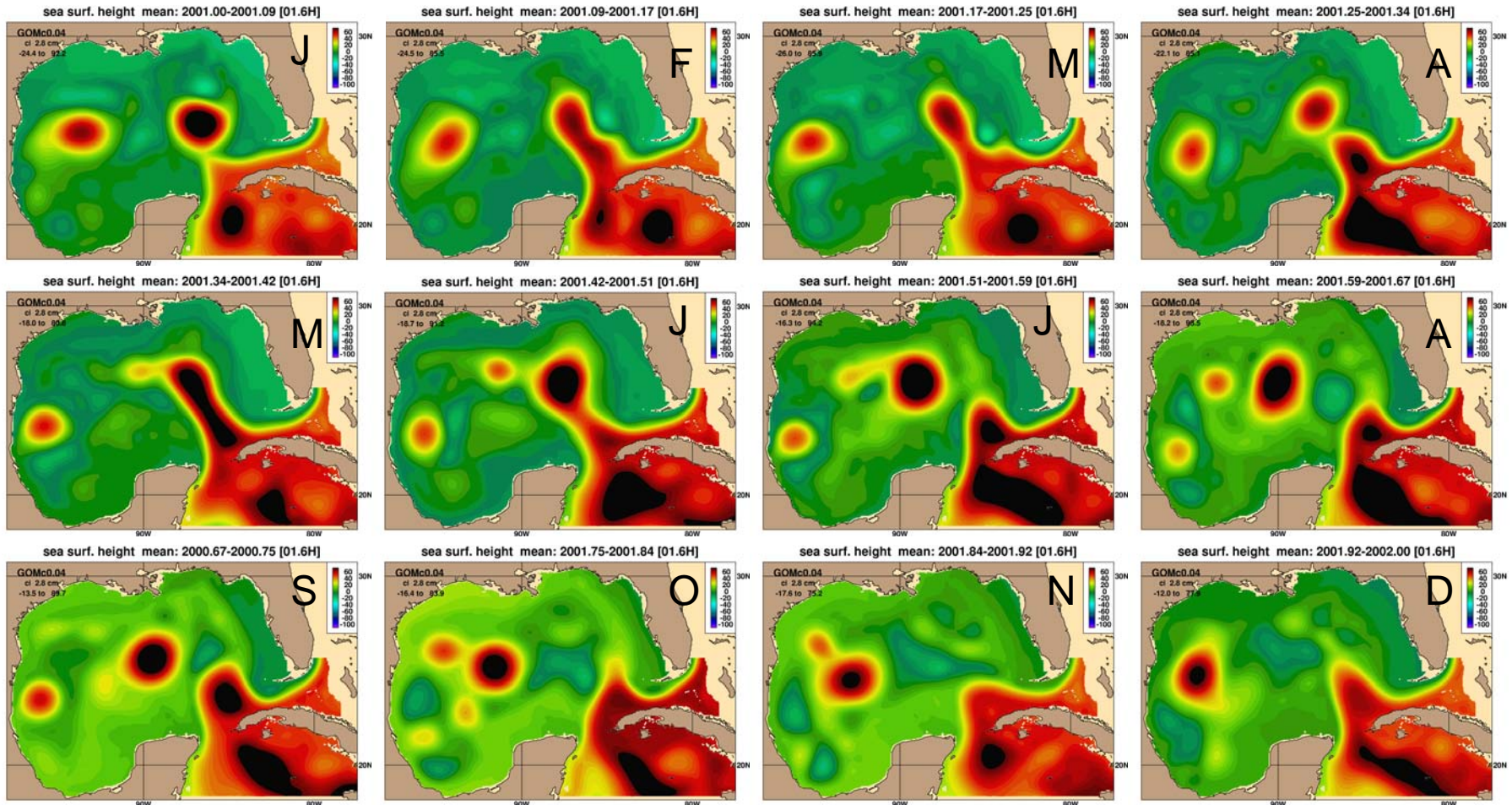


- Loop Current Eddy sheds in August 2000
- Role of cyclones in Loop Current Eddy shedding evident

1/25° Nested Gulf of Mexico HYCOM

Monthly Mean Sea Surface Height Year 2001

Evolution of Loop Current Eddy Shedding



- Loop Current Eddy sheds 10 months later (July 2001)
- Detached eddy reattaches in several cases

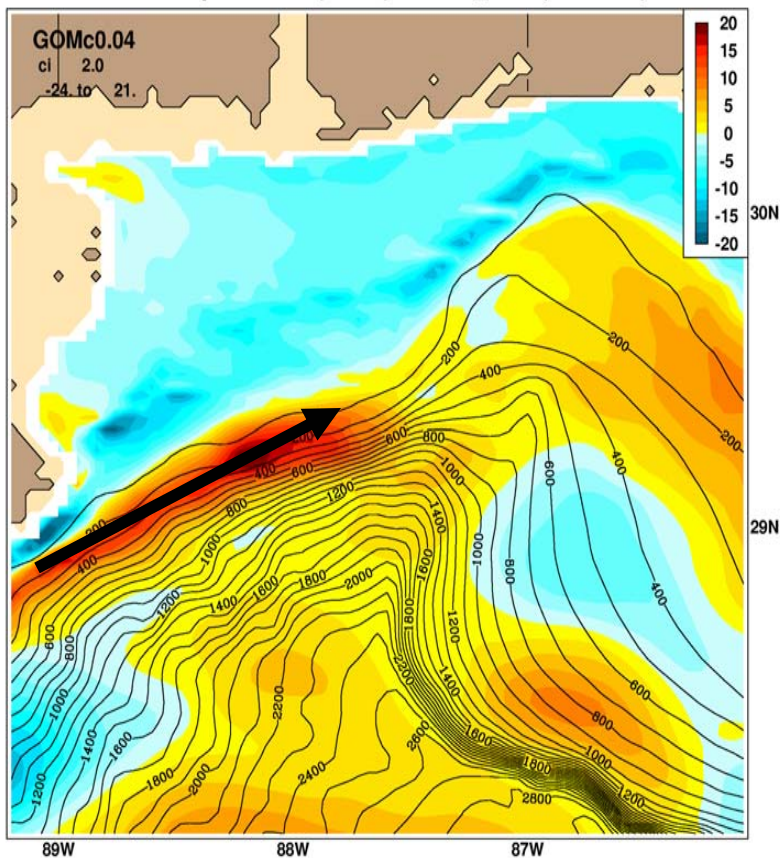
1/25° Nested Gulf of Mexico HYCOM

red=east blue=west

July 27, 2000

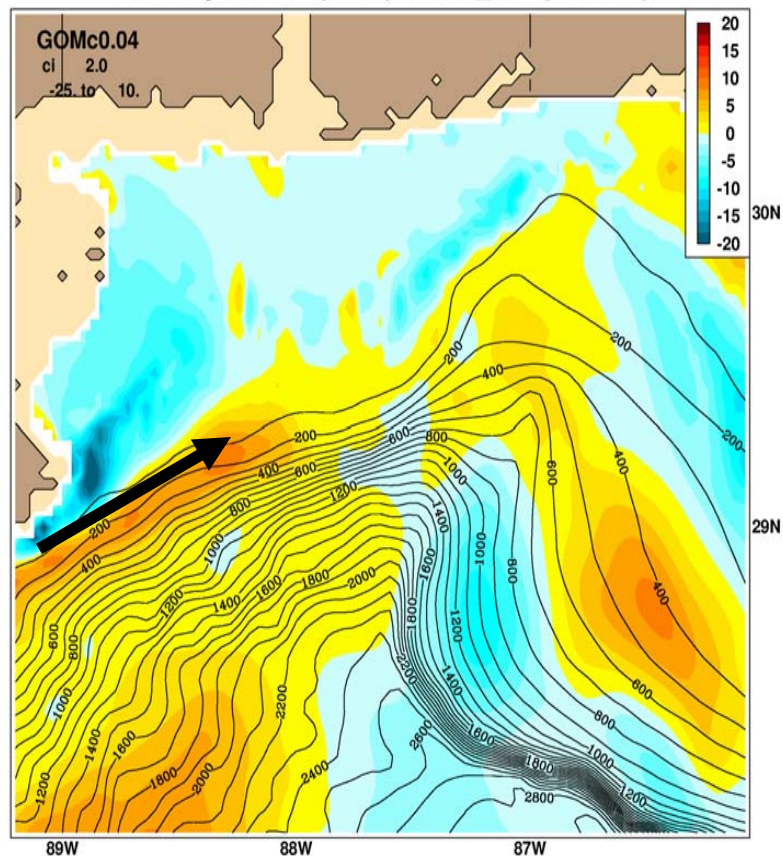
red=north blue=south

Barotropic u-vel (cm/s) - 2000_208 (archive)



Barotropic u-velocity

Barotropic v-vel (cm/s) - 2000_208 (archive)



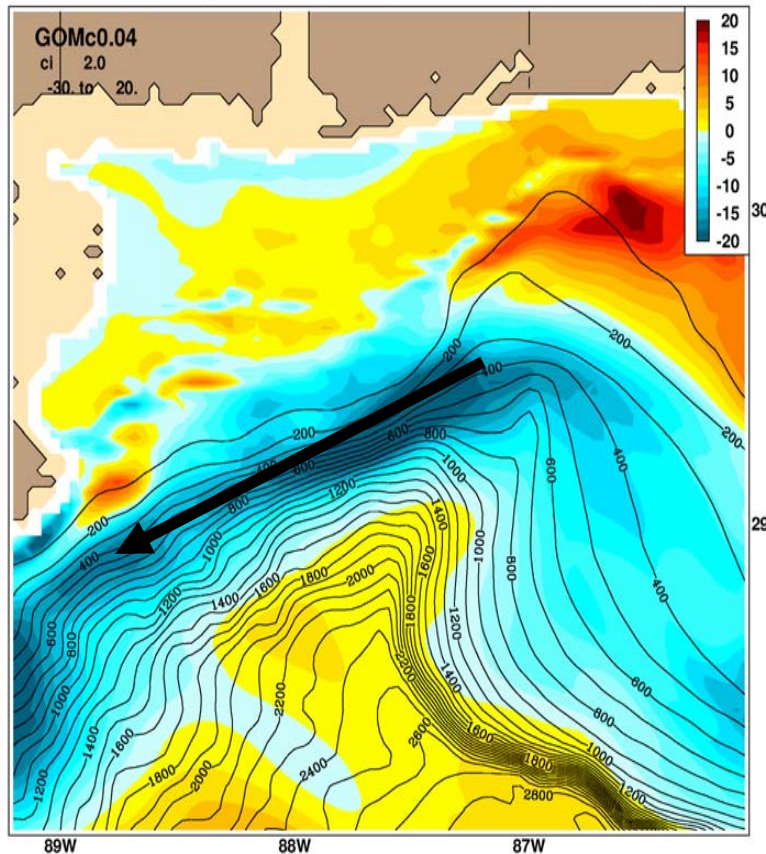
Barotropic v-velocity

**Initial eastward along-shelf break current
in geostrophic balance**

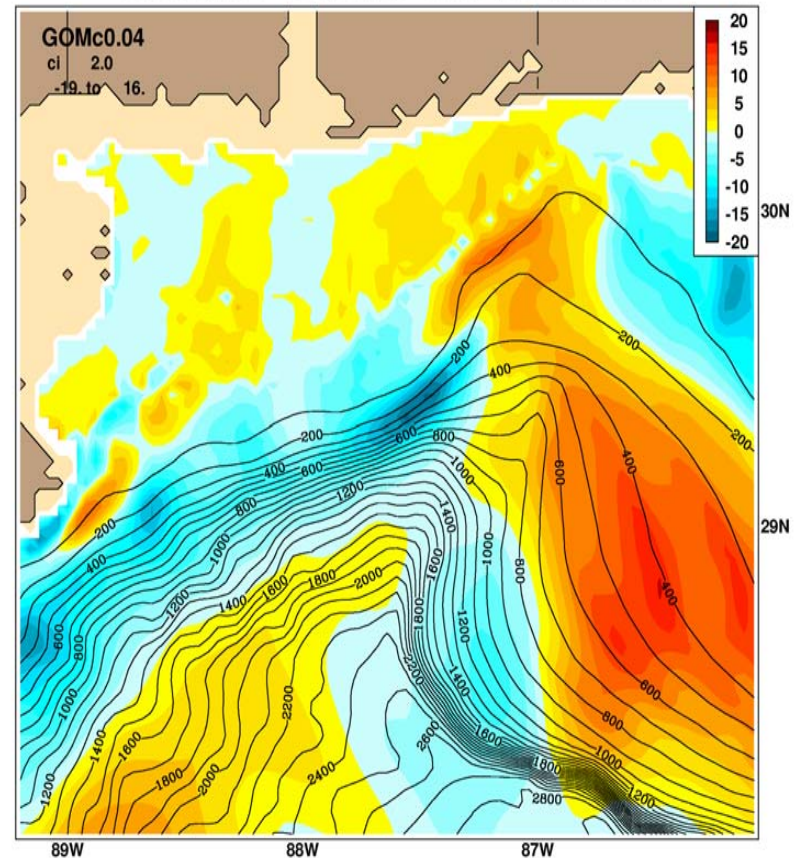
1/25° Nested Gulf of Mexico HYCOM

red=east blue=west August 12, 2000 (+ ~2 weeks) red=north blue=south

Barotropic u-vel (cm/s) - 2000_224 (archive)



Barotropic v-vel (cm/s) - 2000_224 (archive)

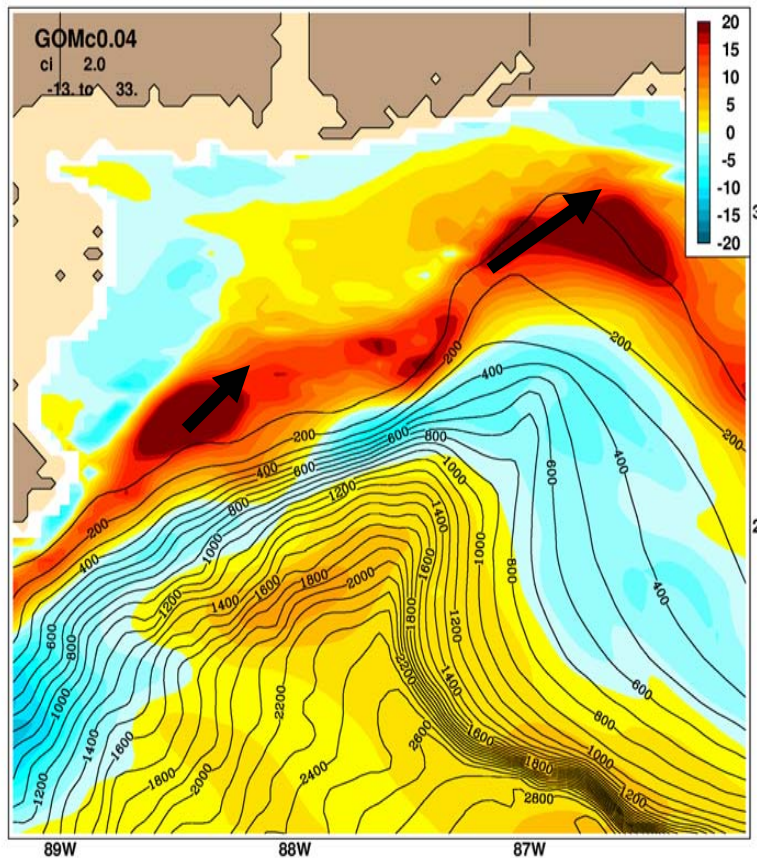


A reversal in the barotropic currents triggers a transition of the along-shelf break currents to flow onto the shelf

1/25° Nested Gulf of Mexico HYCOM

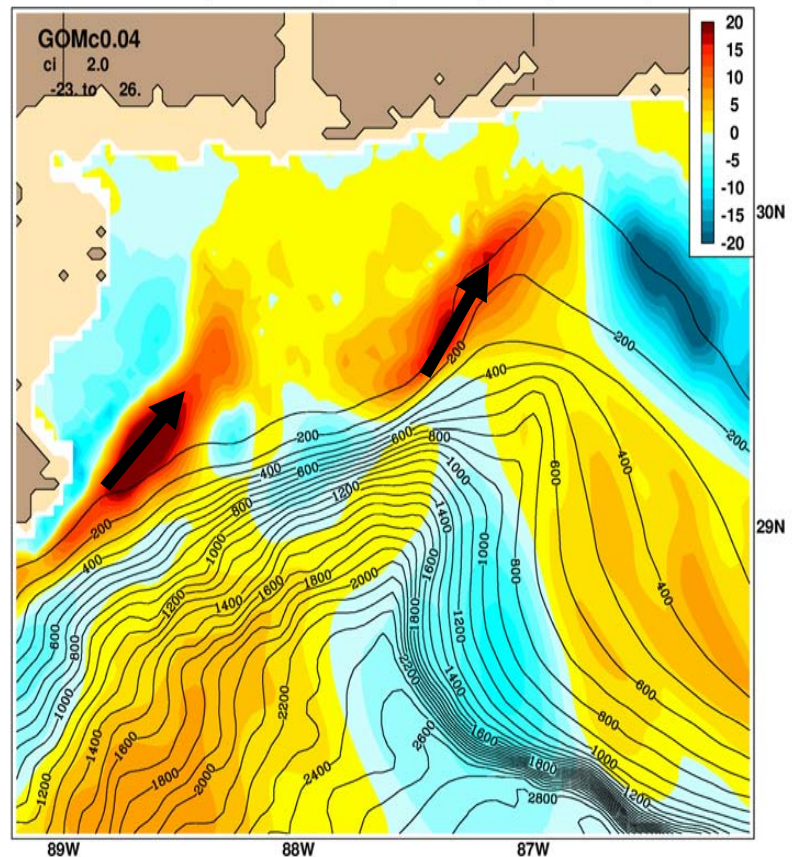
August 18, 2004 (+ ~1 week)

Barotropic u-vel (cm/s) - 2000_230 (archive)



red=east blue=west

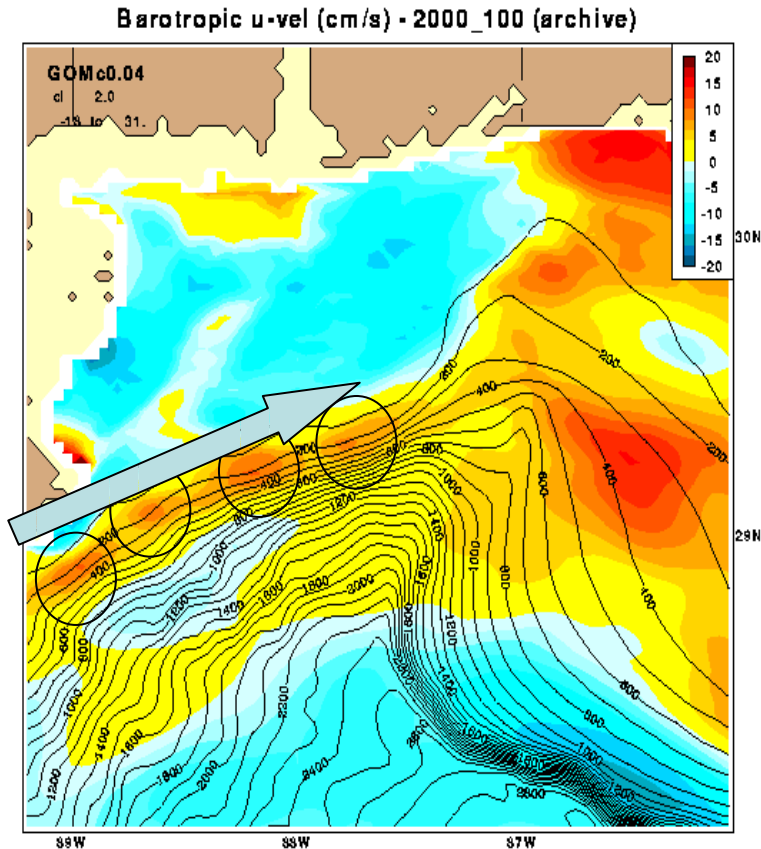
Barotropic v-vel (cm/s) - 2000_230 (archive)



red=north blue=south

Significant cross-shelf flow exists after the reversal

1/25° Nested HYCOM forced by NOGAPS



Jet flowing eastward
along isobaths

The depth changes in
isopycnals across the current
serve as a potential energy
source for baroclinic eddies

Shelf break eddies associated
with baroclinic instability of the
along shelf-break current

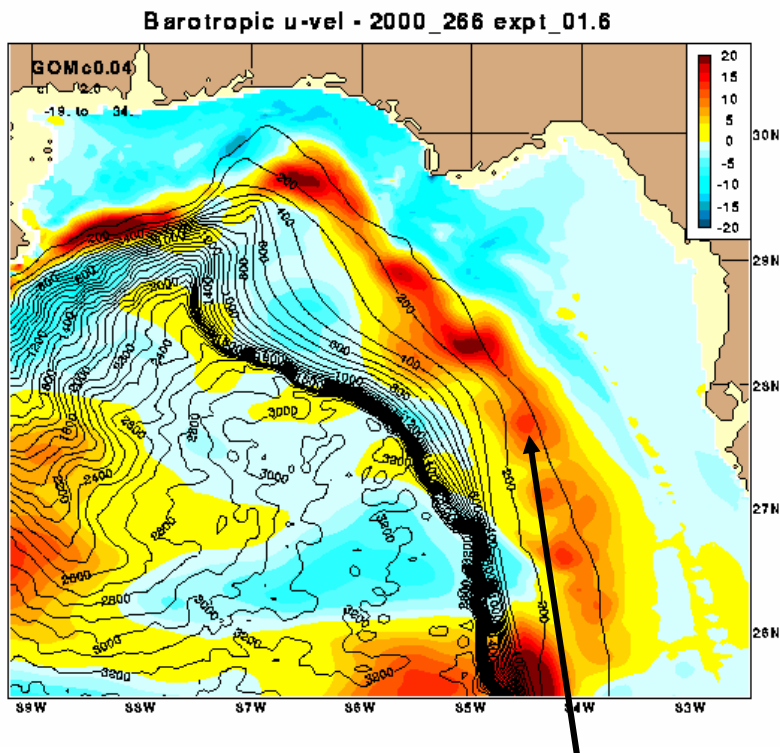
April 10, 2000

red=east blue=west

1/25° Nested Gulf of Mexico HYCOM

Barotropic u-velocity

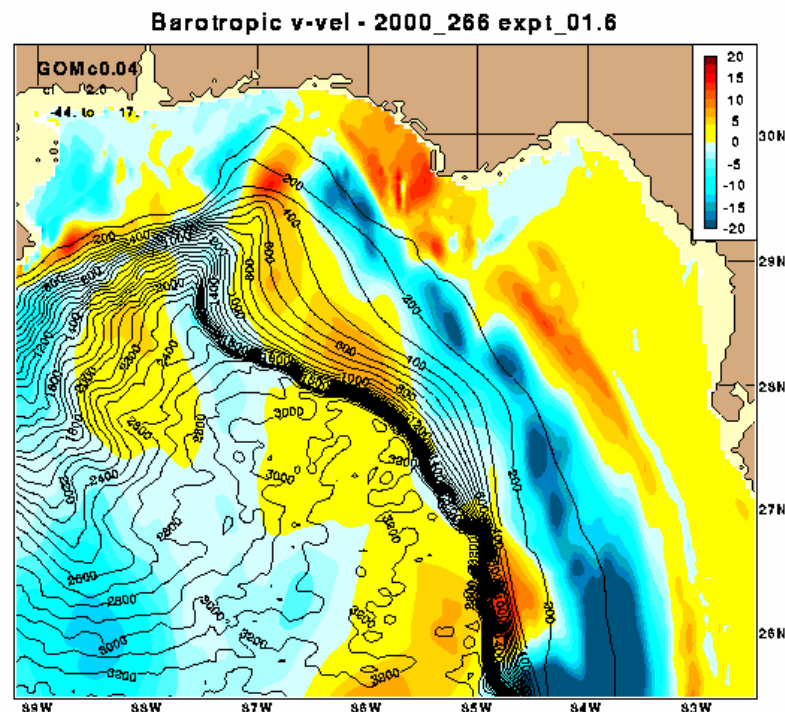
red=east blue=west



Meandering of the along-shelf jet

Barotropic v-velocity

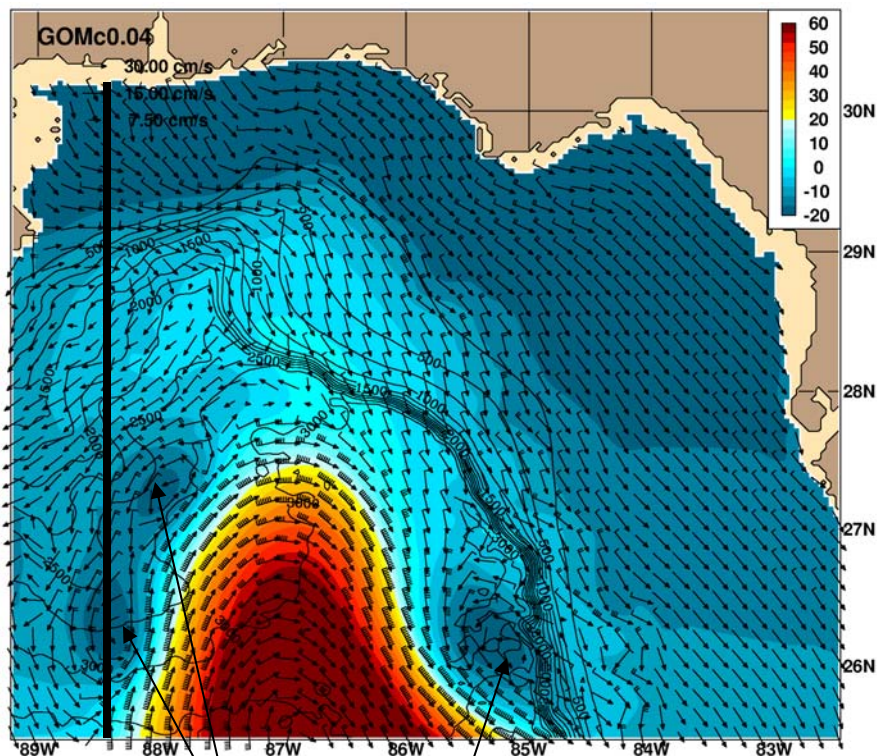
red=north blue=south



Clockwise along-shelf break flow common in eastern Gulf

1/25° Nested Gulf of Mexico HYCOM

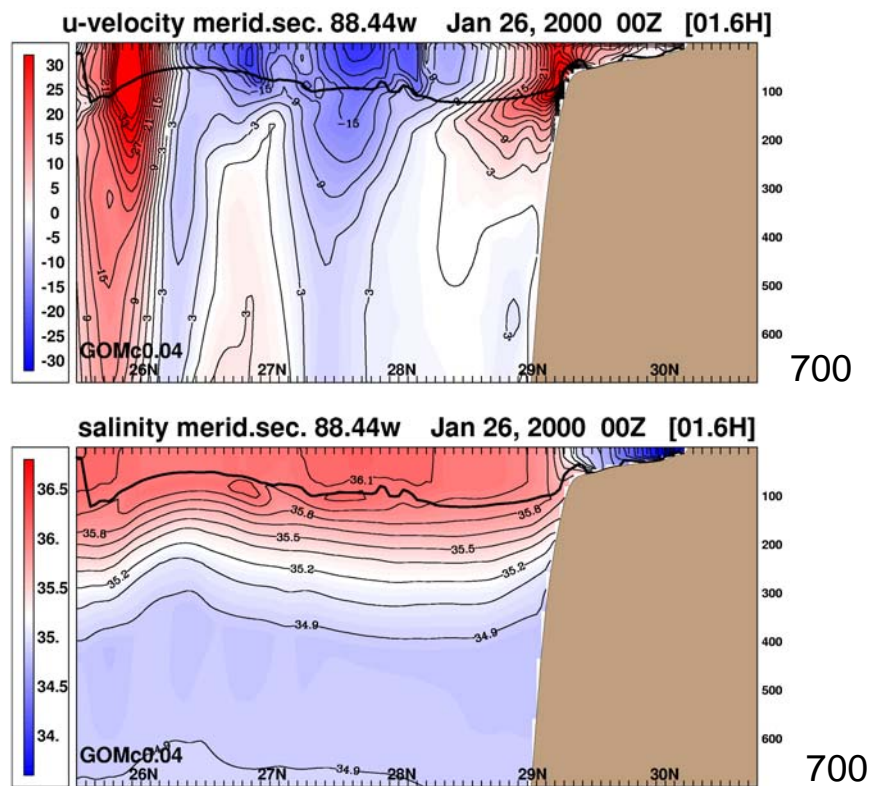
Jan 26 2001 SSH and Surface Currents



cyclones

- Cyclone cores are ~700m deep
- Robust shelf-break current associated with strong salinity gradient
- Loop Current penetration to ~28°N

Cross-section along 88.4°W

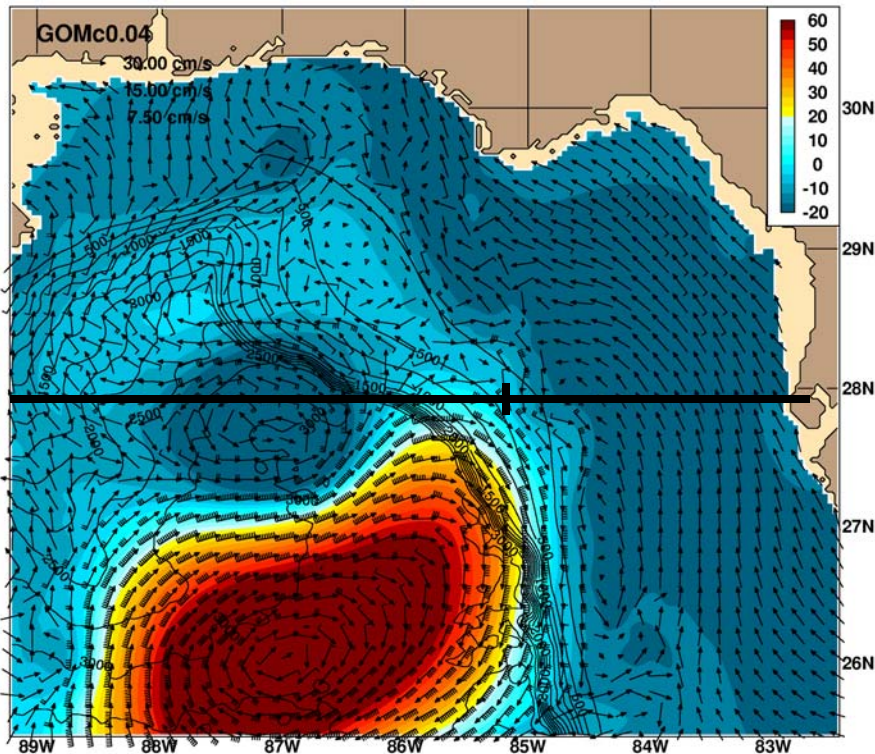


Red=east
Blue=west

1/25° Nested Gulf of Mexico HYCOM

Red=north
Blue=south

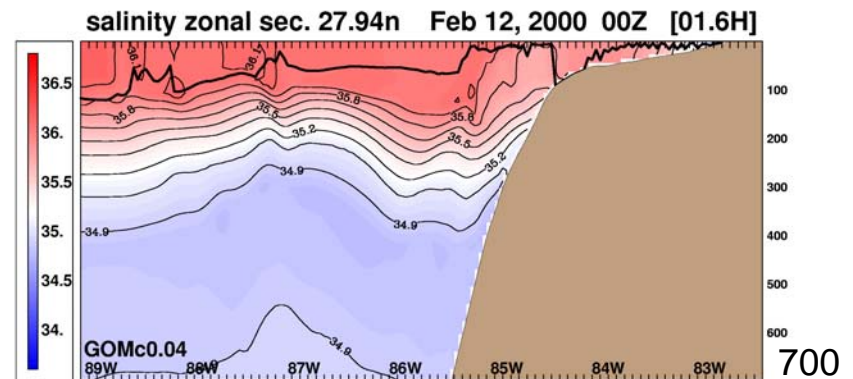
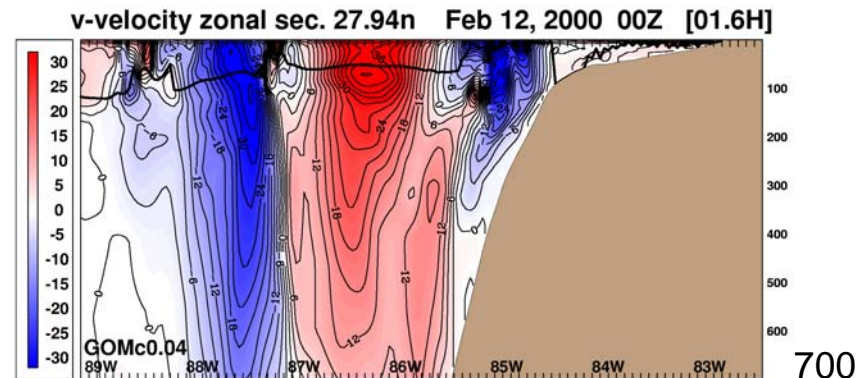
Feb 12, 2001 SSH and Surface Currents



Loop Current has migrated to NE
and is impinging on shelfbreak

Cyclone also impinging on shelfbreak

Cross-section along 27.9°N

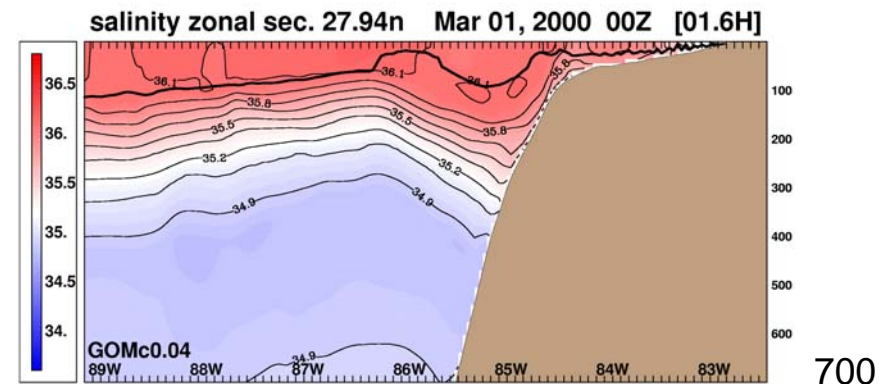
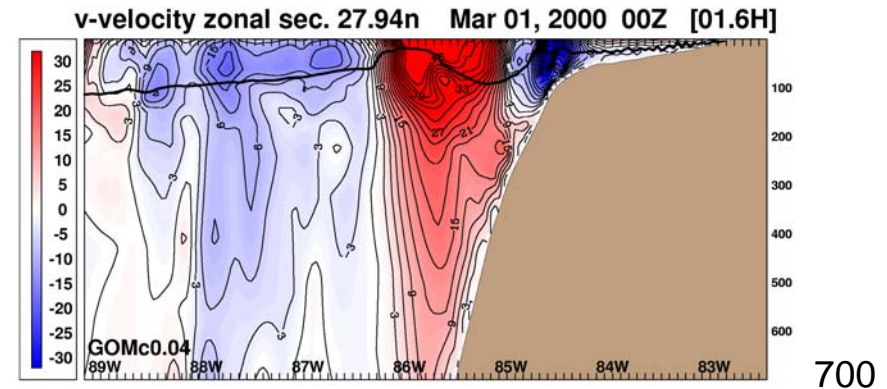
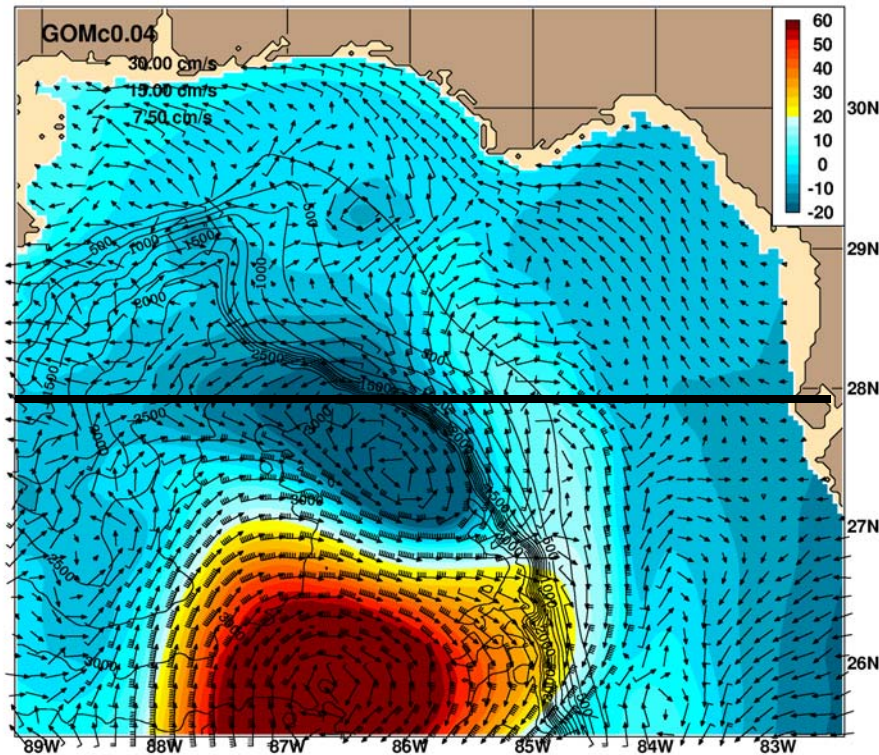


- Doming of isohalines associated with cyclone
- Sharp shelfbreak front
- Intense northward subsurface jet

1/25° Nested Gulf of Mexico HYCOM

Red=north
Blue=south

March 01, 2001 SSH and Surface Currents



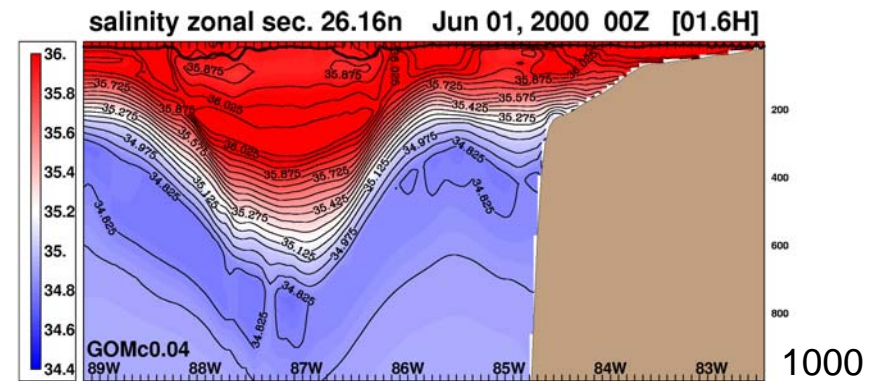
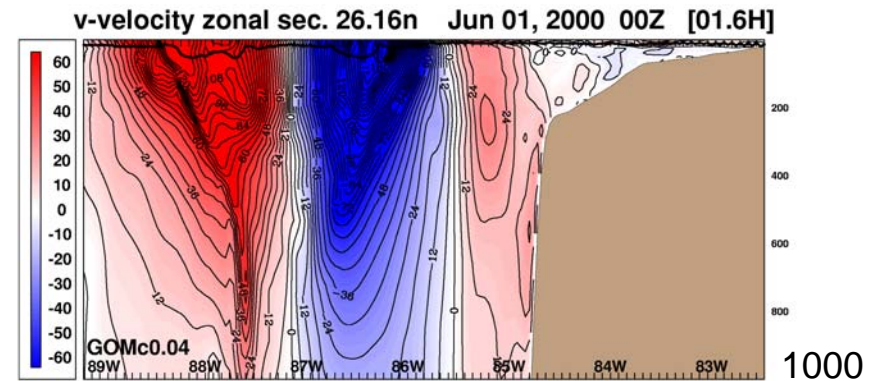
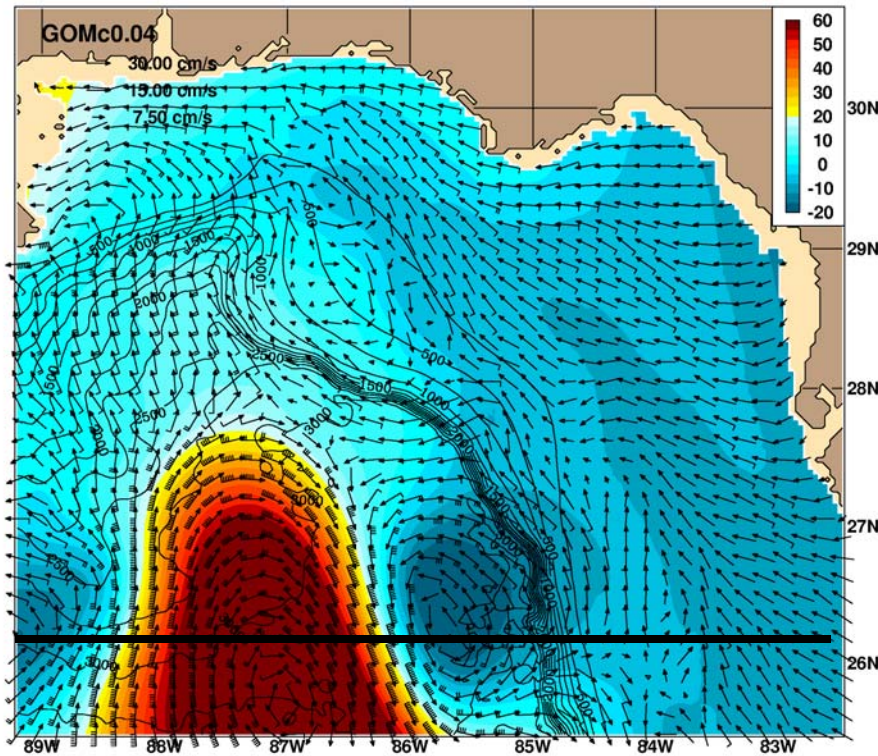
- Cyclone orbiting Loop Current Eddy,
- Loop Current Eddy breaching shelf break
- Southward flow enhanced by vortex compression?

Southward subsurface velocity maximum

1/25° Nested Gulf of Mexico HYCOM

Red=north
Blue=south

June 02, 2001 SSH and Surface Currents

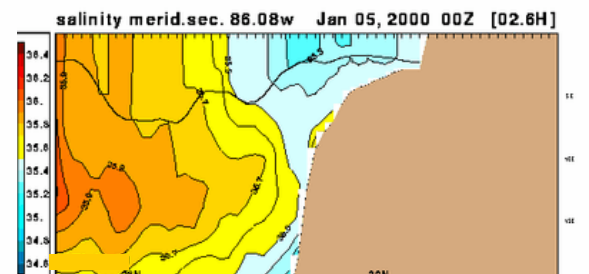
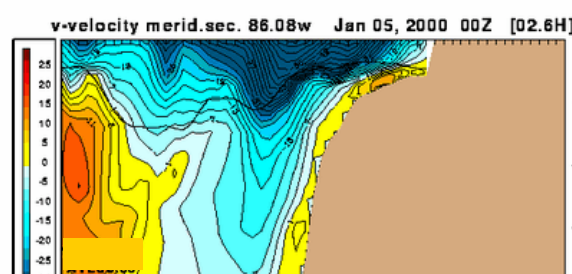
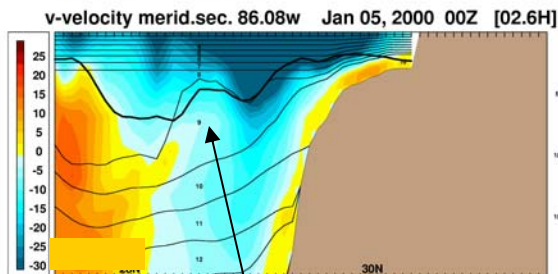
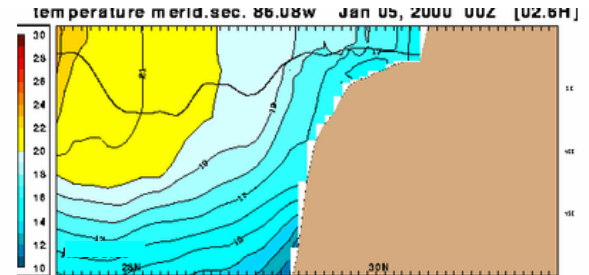
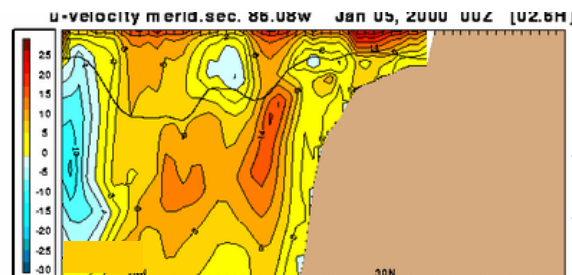
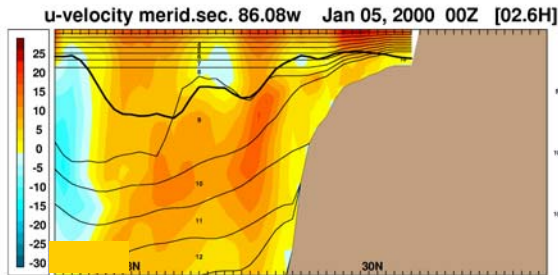
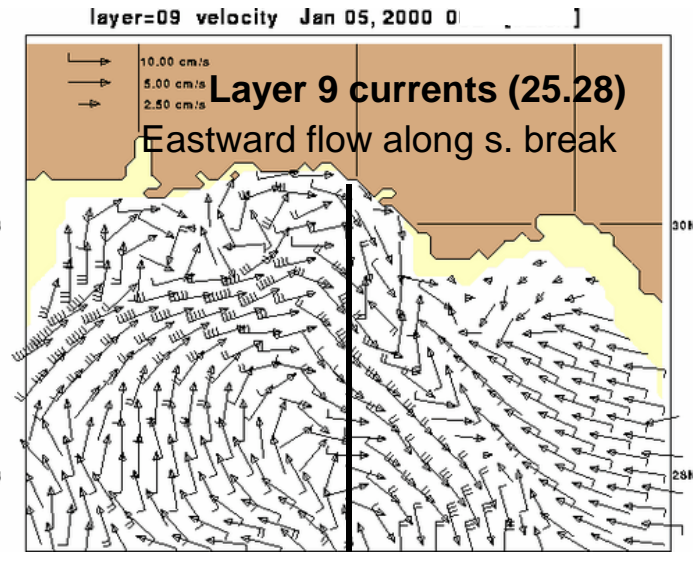
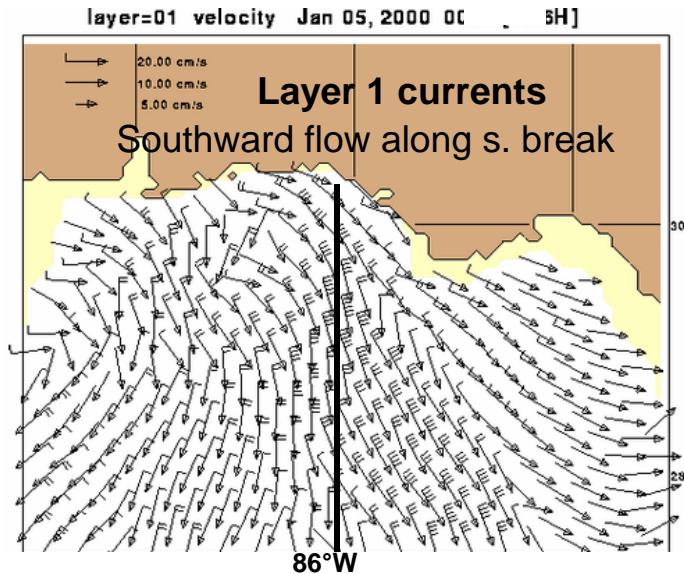


3 months later cyclone hasn't migrated very far but is being steered by the shelf break

- Strange symmetry of LCE especially on western side
- Subsurface salinity max beneath LCE

January 05, 2002

Upwelling in the northern Gulf of Mexico



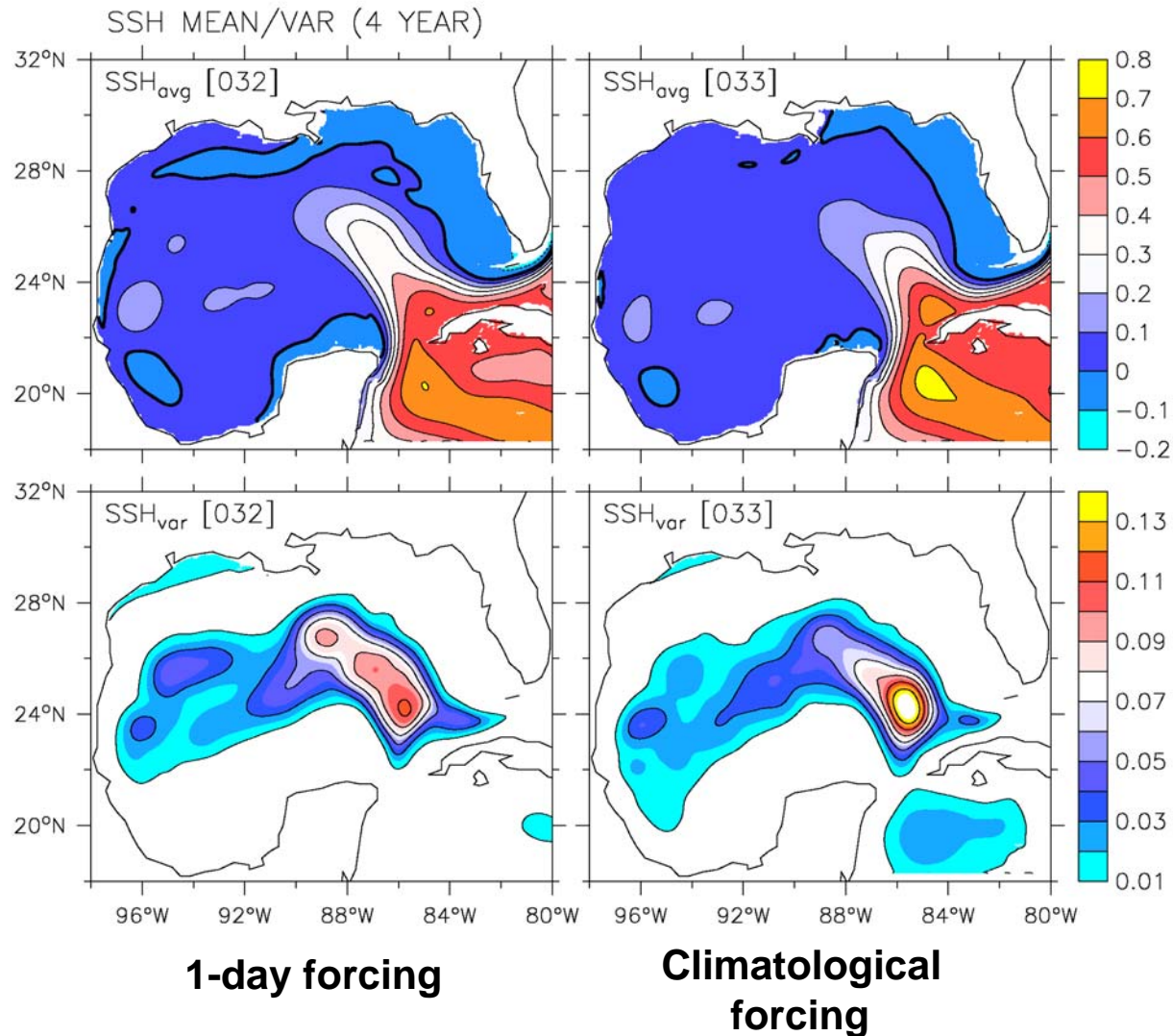
Layer 9

Northward velocity along shelf

Upwelling of cold water

Sensitivity of boundary forcing updating

Allows for long-term integrations over any timeframe



Monthly climatology formed from 1-day archives

Conclusions

Value of 2x resolution clear (cyclones, filaments, etc)

3 primary mechanisms of cross-shelf exchange:

- Along-shelf flow instabilities
- Along-shelf flow reversals
- Eddy-eddy interactions
- Influence of topography

Upwelling well represented (Yucatan, northern Gulf)

Climatological boundary forcing doesn't appear to
Degrade the solution

SUPPLEMENTAL SLIDES FOLLOW

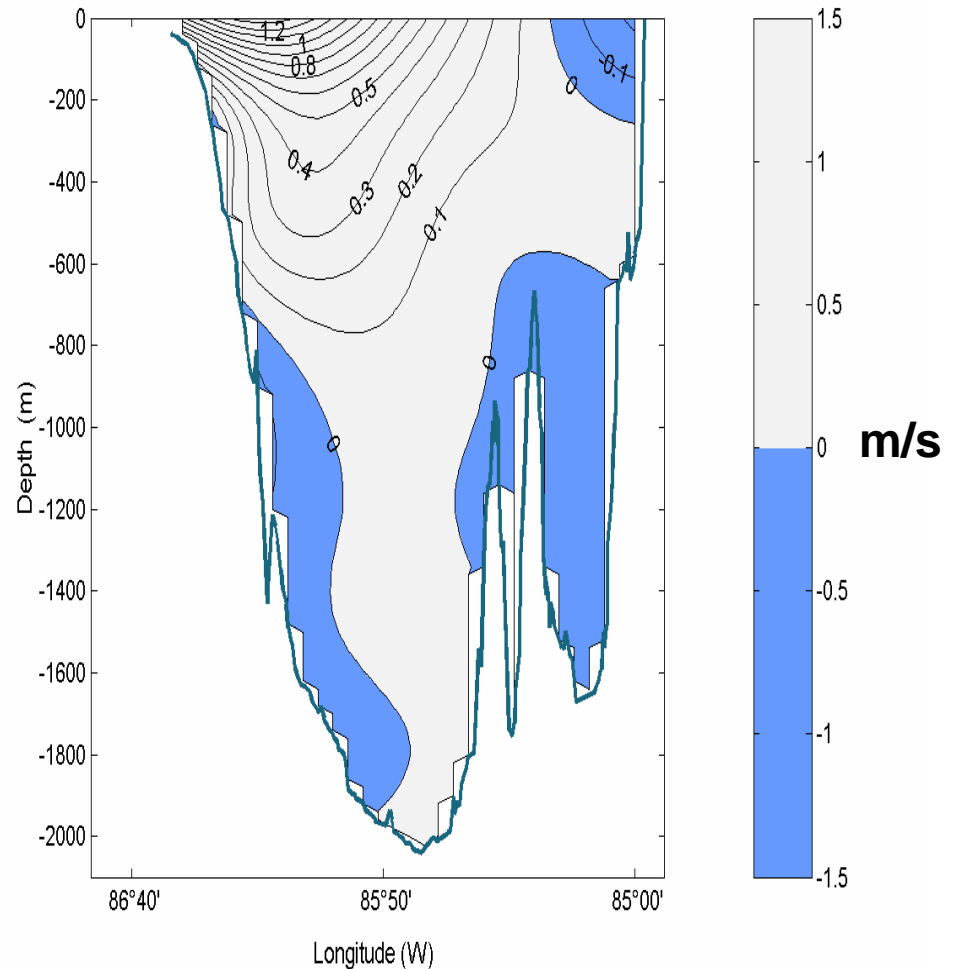
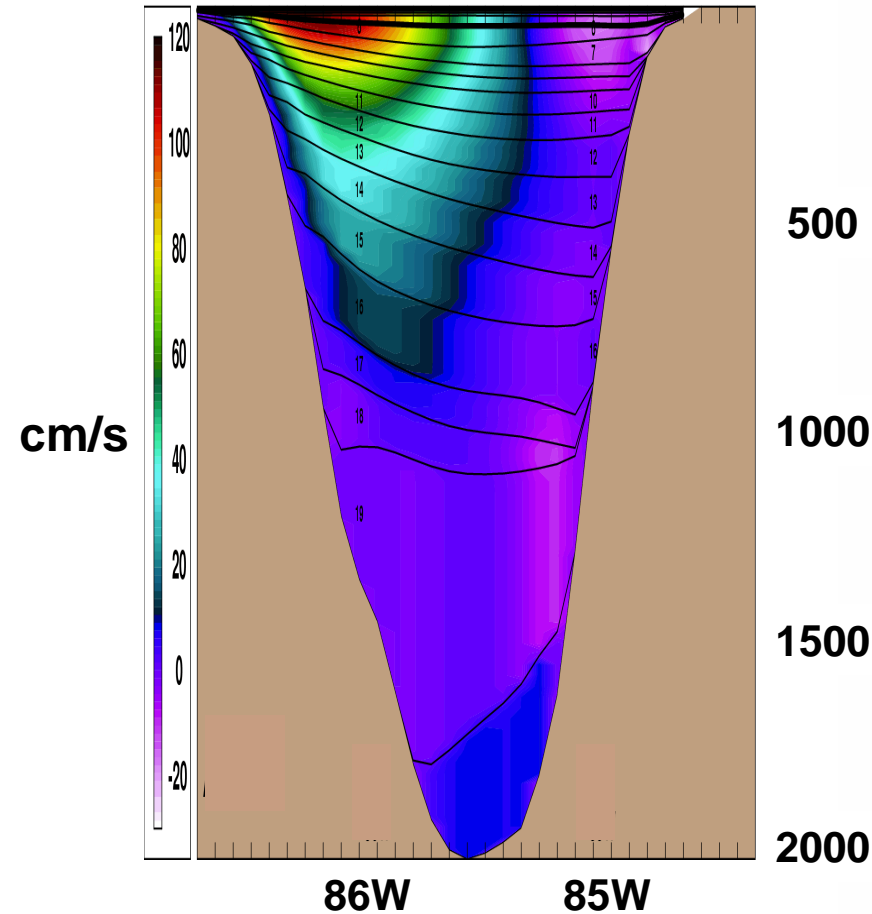




Yucatan Channel Normal Velocity

0.08° ATL HYCOM 1-Year Mean

Observed Mean 8/1999-6/2000
(Abascal, et. al, 2001)



Note: section and sample period not identical



1/25° Free-Running Gulf of Mexico HYCOM

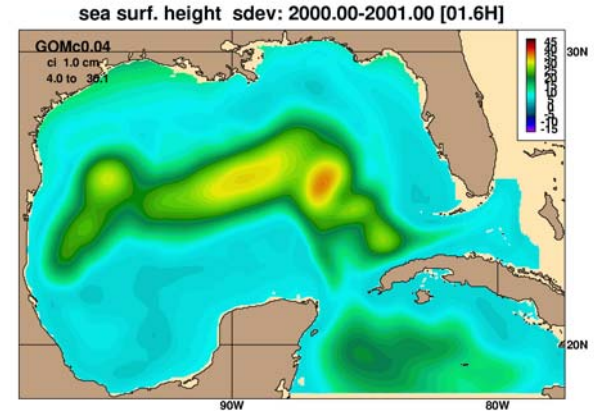
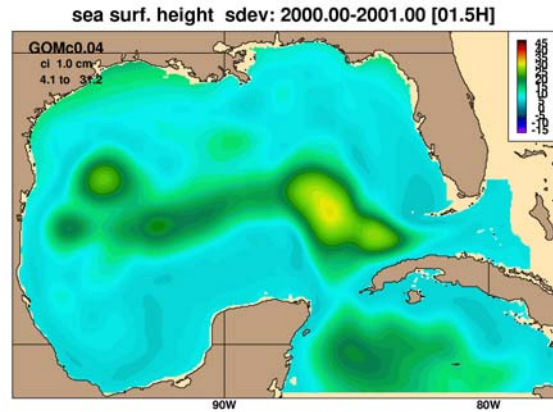
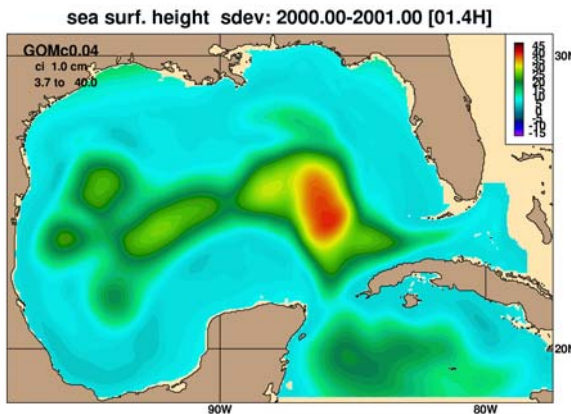
RMS SSH Variability

KPP

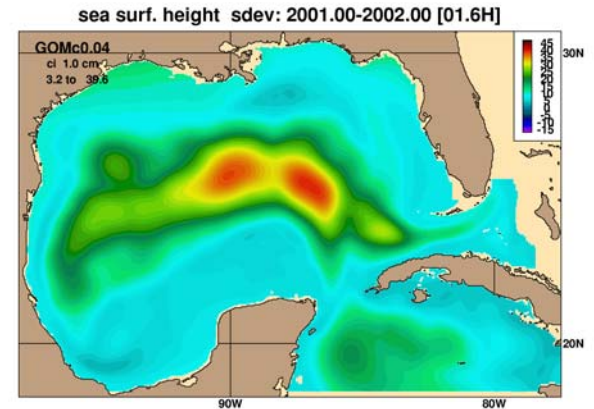
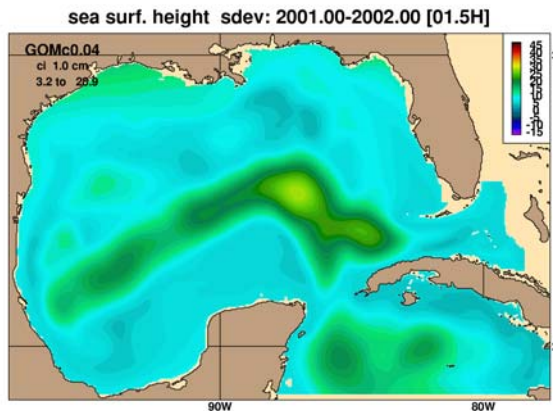
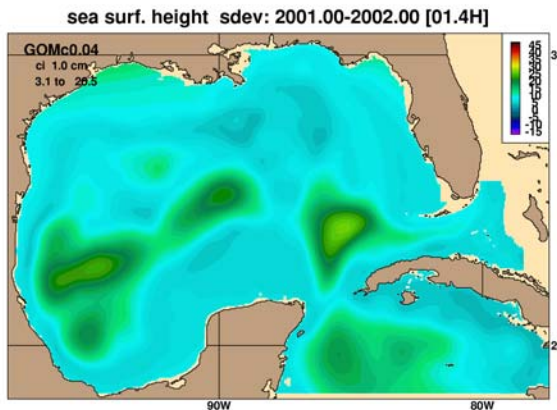
MY-2.5

GISS

2000



2001

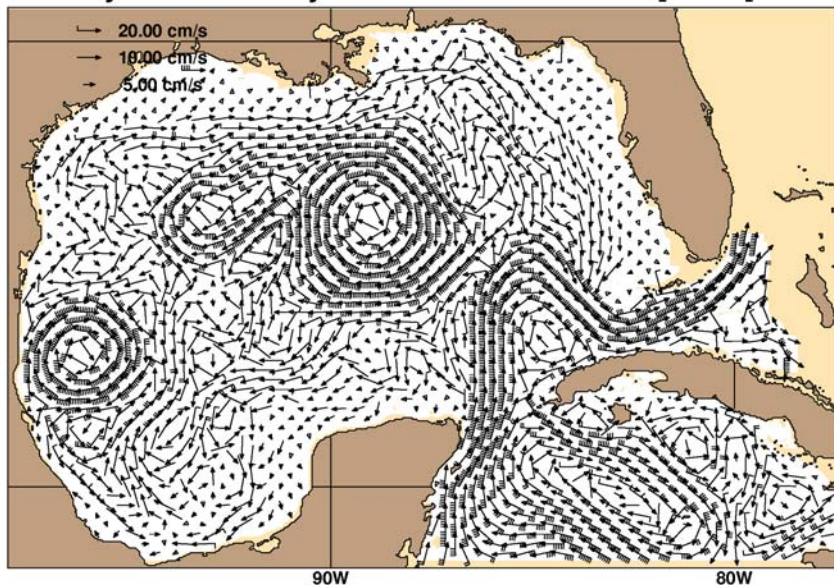


KPP variability low in 2001

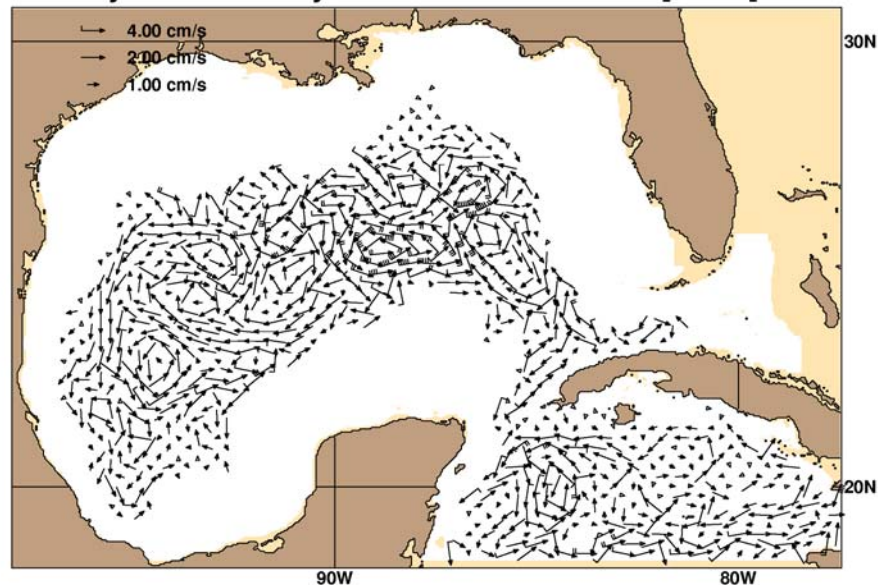
MY-2.5 variability low in 2000 and 2001

Need longer time series for meaningful statistics

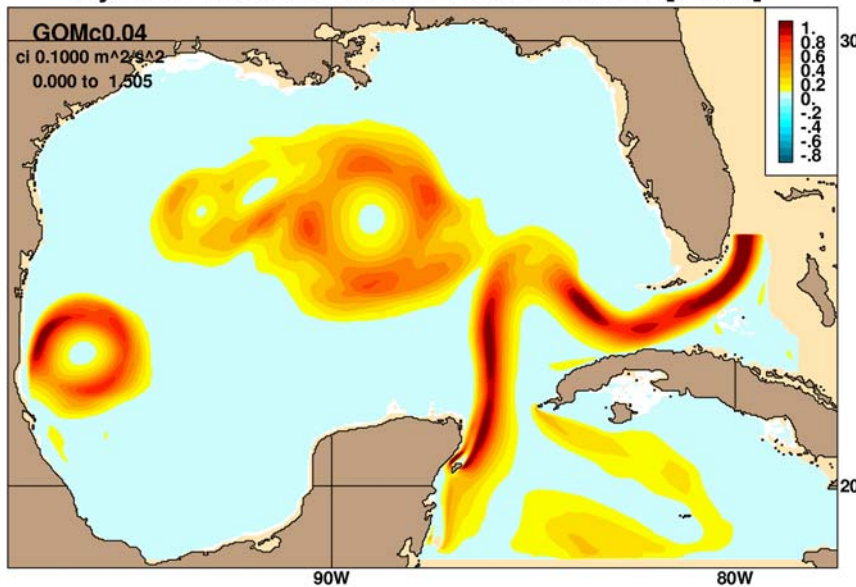
layer=07 velocity mean: 2001.51-2001.59 [01.6H]



layer=20 velocity mean: 2001.51-2001.59 [01.6H]



layer=07 ke/mass mean: 2001.51-2001.59 [01.6H]



layer=20 ke/mass mean: 2001.51-2001.59 [01.6H]

